Experimental Nano-Fluidics

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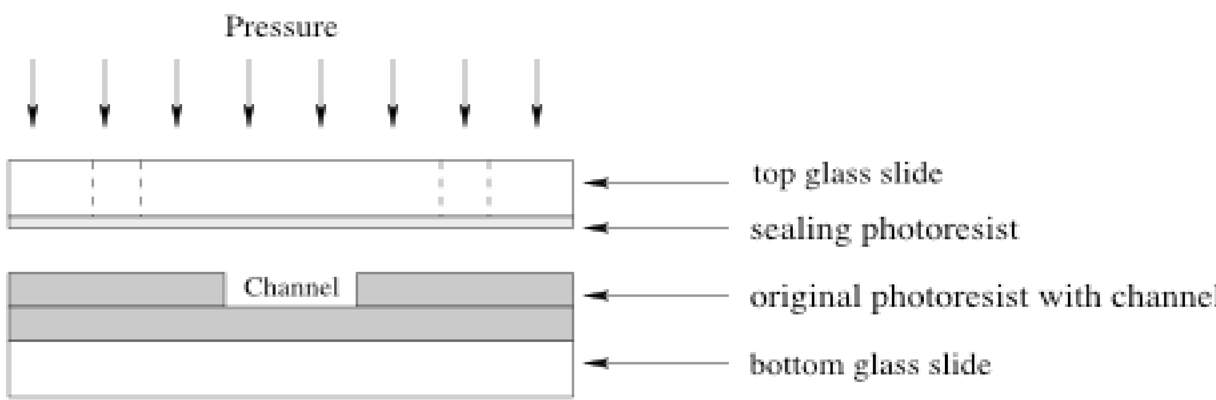
In recent years there have been spectacular advances in our ability to fabricate, manipulate, and probe materials at very small, i.e., “nano-”size scales. Much of this work has focused on conducting materials (such as semiconductors and metals), and the many novel aspects of electron motion in such systems. Attention is now beginning to turn to questions concerning fluid flow in nano-scale structures. We have developed methods for making nano-structures for the containment and manipulation of fluids. These and similar structures might be used for the study of chemical and biological reactions involving very small numbers of molecules. The figure below shows how we have adapted lithographic techniques (which have been previously developed to study semiconductors and metals) to make fluid flow structures. The desired flow pattern is first transferred photographically into a photoresist layer (a light sensitive polymer). This pattern - denoted as the “channel” in the figure - forms the floor and sidewalls of a flow channel. The ceiling is formed by a separate layer which is bonded from above. We have used this method to make channels with heights as small as 40 nanometers - about 200 atomic layers thick. A key aspect is that we have precise control on all of the channel dimensions.



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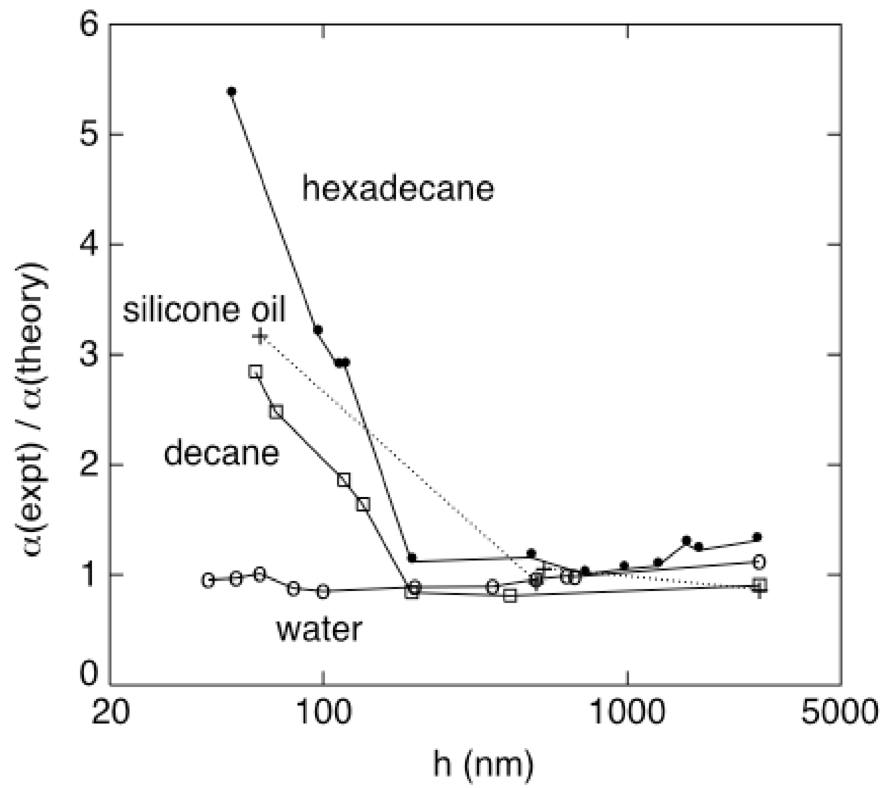
This figure shows results for the flow of several different fluids through our nano-channels. A normalized flow rate of unity corresponds to the theoretically expected rate assuming that the fluid molecules at the walls of the channel are "pinned" by their attraction to the walls. We have found that several fluids, such as the lubricant hexadecane, flow much more readily than this when the channel height (h) is reduced below about 100 nanometers, indicating that the molecules at the walls are not fully pinned. These higher than expected flow rates are currently a challenge to the theory, and will likely be relevant to the performance of practical nano-fluidic devices.



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